

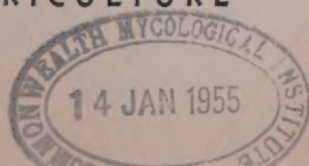
INSECTS and DISEASES of

the PECAN and their control



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Contents

	Page		Page
Insects of the pecan.....	3	Diseases of the pecan (Con.)	
Hickory shuckworm.....	3	Thread blight.....	43
Pecan nut casebearer.....	6	Gnomonia leaf spot.....	43
Pecan weevil.....	8	Pink mold.....	44
Black pecan aphid.....	12	Lichens.....	45
Plant bugs.....	14	Spanish-moss.....	46
Pecan leaf casebearer.....	16	Injury caused by climatic factors...	47
Spittlebug.....	17	Winter injury.....	47
Fall webworm.....	18	Sunscald.....	47
Walnut caterpillar.....	19	Lightning injury.....	47
Twig girdler.....	21	Spraying materials and methods....	49
Pecan phylloxera.....	22	Insecticides.....	49
Obscure scale.....	23	Nicotine sulfate.....	49
Mites.....	23	Lead and calcium arsenates....	49
Flatheaded apple tree borer.....	24	DDT.....	49
May beetles.....	25	Summer-oil emulsions.....	50
Red-shouldered shot-hole borer....	26	Dormant-oil emulsions.....	50
Curculios.....	26	Parathion.....	50
Diseases of the pecan.....	27	Dinitro compounds.....	50
Scab.....	27	BHC and lindane.....	50
Rosette.....	30	Toxaphene.....	50
Downy spot.....	33	TEPP.....	51
Vein spot.....	34	Precautions.....	51
Leaf blotch.....	35	Fungicides.....	51
Brown leaf spot.....	36	Bordeaux mixture.....	51
Liver spot.....	37	Ziram and zineb.....	52
Crown gall.....	38	Spraying machines.....	52
Bunch disease.....	38	Water supply.....	53
Wood rot.....	40	Applying spray materials.....	53
Cotton root rot.....	41	General spray programs for insect and	
Powdery mildew.....	41	disease control.....	53
Nursery blight.....	42	Names of pecan insects.....	56
		Pecan diseases and causal organisms..	56

This publication supersedes Farmers' Bulletin 1654, Insects of the Pecan and How To Combat Them, and Farmers' Bulletin 1672, Diseases of Pecans in the Southern States.

INSECTS AND DISEASES OF THE PECAN AND THEIR CONTROL¹

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MANY kinds of insects and disease organisms attack pecan trees and threaten the crop of nuts. They do this in several ways. Of the insects, some damage the bark or heartwood, others tunnel or girdle the branches so that they may break off, and still others attack the buds, leaves, or nuts. Some kinds are present throughout the growing season, and others for shorter periods, either early or late.

Disease organisms, principally fungi, that infect the pecan usually attack the growing tissues, including leaves, shoots, and nuts. In seriously affected orchards, trees may be so badly injured that most of the leaves are shed or practically all of the nuts are lost. Disease spreads most rapidly early in the growing season during periods of damp weather.

In the last few decades pecan

growing has become a sizable industry. This development has brought new problems in controlling insects. Large acreages of pecan orchards provide an abundant supply of the preferred food of these insects, hence they increase rapidly. In addition to the species that have followed the pecan from its native habitat, others have transferred from hickories and related trees nearby. Attacks on the pecan by disease-producing organisms have also become more serious.

The pecan grower must control harmful insects and diseases if he is to obtain a profitable crop of nuts. But first he must know what insects and disease-producing organisms are affecting his trees. Certain cultural practices will keep some of them from causing much damage; against others, spraying is necessary.

INSECTS OF THE PECAN

HICKORY SHUCKWORM

The most destructive insect that infests the pecan is the hickory shuckworm. It attacks the nuts from about the middle of June until harvest. It tunnels in and destroys the interior of the nuts (fig. 1) until the shells harden late in August. The affected nuts fall to the ground. At least half the crop may be lost in this way, especially when there is a light set. After the shells have hardened, the larvae tunnel in the shucks, preventing the kernels from developing properly.

Nuts heavily infested by shuckworms are likely to be poorly filled and to mature later than those free from this pest. Injured portions of the shuck sometimes stick to the nuts and interfere with processing. The shells are often stained.

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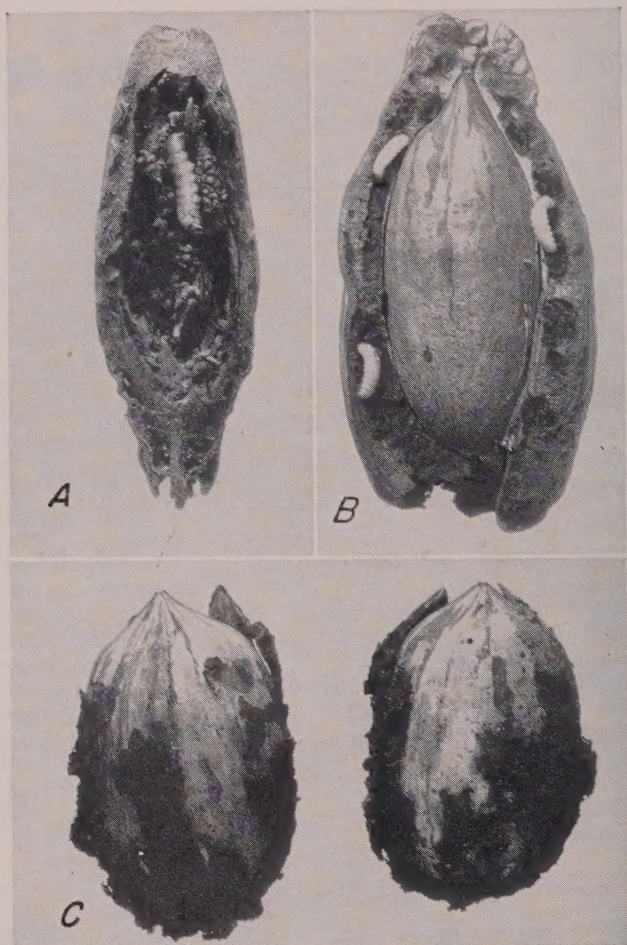


Figure 1.—Damage caused by larvae of the hickory shuckworm: A, Larvae in immature nuts; B, larvae mining the shuck of a nearly mature nut; C, nuts showing adhering portions of damaged shucks and shell stains.

The shuckworm also feeds on hickory nuts, causing injury similar to that done to the pecan. Early in the spring it may feed in phylloxera galls (see page 22).

The insects pass the winter as full-grown larvae in the shucks on the ground. These larvae transform to pupae and the pupae into dark, inconspicuous moths, which

in southern Georgia begin to appear the middle of February. Most of the moths of this generation emerge in April, but small numbers continue to appear throughout the summer. The spring development of the insect coincides with that of the nuts of native hickories, which set 2 to 3 weeks earlier than those of the pecan. Only the late-emerging

moths of the spring brood lay their eggs on the foliage and small nuts of the pecan.

Few pecan nuts can be found infested with shuckworms before the middle of June. Thereafter their numbers increase rapidly with successive generations, of which there are four or five in southern Georgia.

nary disk harrow merely stirs up the soil and does not cover the drops sufficiently. Turn under the drops about July 15 and again about 3 weeks later, particularly under the spread of the branches, where most of the injured nuts fall.

If the orchard received little or no cultivation in former years, set



Figure 2.—Disk tiller in operation for control of the hickory shuckworm.

Control

No satisfactory control of the shuckworm is known. A reduction in injury of about 50 percent is possible, where soil conditions and cultural practices permit, by keeping the infested nuts that drop covered with soil during July and August. The nuts decay in the soil, thus preventing the larvae from completing their development.

The best way to cover the dropped nuts is to use a disk tiller, sometimes called a tiller plow or Wheatland plow (fig. 2). An ordi-

nary disk tiller to plow only 3 inches deep the first season, to avoid severe root damage. By the second season the root system will have become adjusted to a lower level in the soil. Then set the implement at 4 inches in order to give better coverage of the drops. If you adjust the tiller deeper than 4 inches, you may destroy too many feeder roots.

If you have only a few pecan trees and a disk tiller is not available, use a small, one-horse turning or moldboard plow. Take care not to plow or cultivate deeper than indicated.

PECAN NUT CASEBEARER

The pecan nut casebearer is especially abundant and destructive in certain portions of Texas, but causes damage throughout the Pecan Belt. Losses caused by this insect vary considerably from year to year with the size of the crop. A light to moderate infestation in a heavy set of nuts may merely provide a desirable thinning, but in a

shoots, where they feed until full grown. They transform into the pupal, or resting, stage either in the tunneled shoots or in cocoons that they attach to other parts of the tree.

The rather inconspicuous dark gray moths usually emerge in May. They appear in largest numbers about the time the nuts are setting. They lay greenish-white eggs on the blossom end of the nuts, near



Figure 3.—Winter cocoon of the pecan nut casebearer at the base of a bud.

light crop of nuts may destroy a large percentage of the crop.

The casebearer passes the winter as a partly grown larva in a small, tightly woven cocoon (fig. 3) sometimes called a hibernaculum, which is generally found where a bud joins the stem. The larvae become active in the spring about the time the buds begin to open. They feed for a short time on the buds, and later bore into the young tender

the base of the calyx lobes. Usually one egg only is laid in a cluster of nuts.

Most of the damage by this insect is caused by the first-generation larvae in May and early in June. The newly hatched larvae usually descend from the nut clusters to feed on the buds just below. After a few days they return to the clusters and attack the newly set nuts. Infested nuts are held together by

silken threads (fig. 4). They are easily recognized by the mass of frass cast out by the larvae. In the course of its development a single larva of this generation may destroy from one to all the nuts in a cluster. The larva matures and pupates in one of the last nuts attacked in a cluster (fig. 5).

The moths of the second generation appear in late June and early July. The larvae of this genera-



Figure 4.—Cluster of nuts infested by the pecan nut casebearer.

tion also attack the nuts, but the loss is less, since the nuts are larger and only one or two are required for the development of an individual larva. Larvae of later generations feed mostly on the surface of the shucks and to some extent on the leaves and do little damage. The larvae of the last generation in the season construct cocoons about the buds, in which they overwinter.

Three generations of this insect are most common, although four generations have occurred in Texas.

Control

In general, no control is needed when the nut crop is normal or better and not over about 3 percent of the shoots of the previous year are infested with overwintering larvae. Under all other circumstances, and especially if there is a history of serious infestation, a spray program should be undertaken. Any one of the following sprays is effective:

DDT, 2 or 3 pounds of a 50-percent wettable powder to 100 gallons of water. Use the smaller quantity in the Southeast and the larger quantity elsewhere. DDT is the most effective material known, and its application does not need to be timed so accurately as does that of other materials. However, mites and aphids may become a problem where it is used.

Parathion, 2 pounds of a 15-percent wettable powder to 100 gallons of water. Its residual effectiveness is not so great as that of DDT, but it does control mites and aphids that may be present so that they are less likely to be a problem than when DDT is used. See Precautions, page 51.

Nicotine sulfate (40-percent nicotine), 13 fluid ounces (about $\frac{3}{4}$ pint) plus 2 quarts of a summer-oil emulsion to 100 gallons of water. This is the safest treatment if livestock or other animals are to be grazed in the orchard.

Lead arsenate, 6 pounds to 100 gallons of water. Use this insecticide only in semiarid areas, such as in central Texas. It may cause serious injury to the trees if used in humid areas.

A single application of any of these sprays gives adequate control

of the nut casebearer in most orchards. If the infestation is heavy and the crop below normal, make two applications about a week apart. Make the first application before many first-generation larvae enter the nuts, between about April 20 and May 25. Start spraying when eggs are readily found on the tips of the young nuts. The eggs are very small but large enough to be seen without magnification. In the latitude of Albany, Ga., the usual

a very important one in the control of fungus diseases attacking the leaves or nuts. Any of the insecticides listed above may be combined with one of the fungicides given on pages 51 and 52.

PECAN WEEVIL

The pecan weevil (fig. 6) infests the nuts and causes a serious loss in pecan production in the Piedmont areas of the Southeastern States and some loss in most years in other

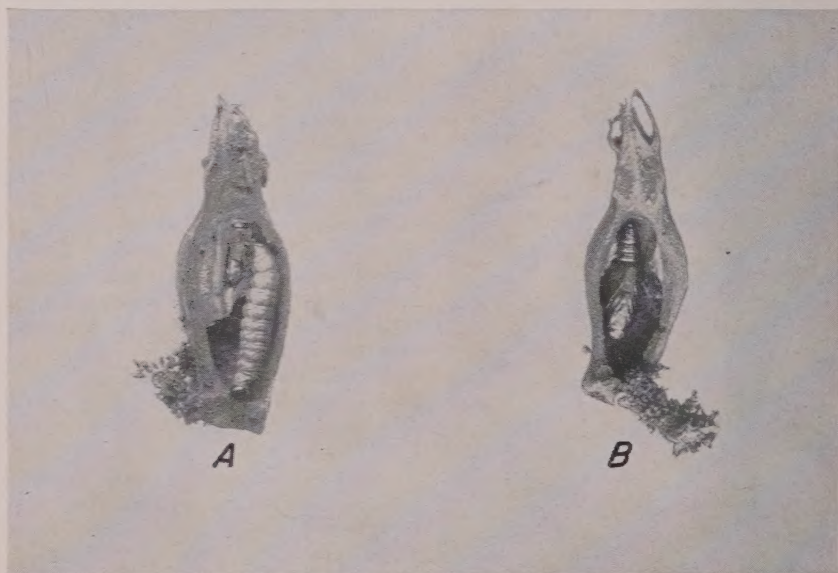


Figure 5.—Larva (A) and pupa (B) of the pecan nut casebearer within small nuts. Enlarged.

date is about May 15, in southern Texas the last of April or the first of May, and in central and northern Texas from May 5 to 25. The timing of the first spray application can be based on nut development and catkin shed. In northern Florida apply the spray about the time the tips of the nuts turn brown, and in other areas about the time catkin shed is complete on such varieties as Schley, Stuart, and Mahan.

This is the first cover spray described on page 54, and it is usually

pecan-producing States. The pest is increasing in abundance throughout the Pecan Belt, particularly in Louisiana, Texas, and Oklahoma.

The weevils do not ordinarily move far from the tree under which they emerge from the soil, provided there is a crop of nuts on that tree. Consequently certain trees may be heavily infested year after year, whereas others of the same variety close by have few, if any, infested nuts. Usually the trees most heavily infested in an orchard are

those growing in the low areas or adjacent to hickory trees.

Pecan varieties differ widely in their susceptibility to attack. Early-maturing varieties, such as Stuart, Schley, Mahan, and Money-maker, are most commonly infested. Late-maturing varieties, such as

types, depending upon the part of the season in which it occurs. Attack before the shell-hardening period in July and August causes all punctured nuts to drop. Attack after the shell-hardening period leads to destruction of the interior of the nut and to adherence of the



Figure 6.—Pecan weevils on Schley pecans.

Success, Teche, Mobile, and Van Deman, are not generally attacked, unless the crop on the early maturing varieties is very light or was destroyed before the insect finished feeding and egg laying. Practically all kinds of hickory nuts are attacked.

Pecan weevil damage is of two

shuck to the shell. Weevil-injured nuts of the second type contain grubs (fig. 7) that destroy the kernels, or they contain holes about $\frac{1}{8}$ inch in diameter through which mature grubs have escaped after destroying the kernels.

The first type of damage often passes unnoticed. However, the

entire crop may be lost if weevils are abundant and the crop is light. Such damage may be heavy even when a large crop is attacked. The second type of damage is generally noticeable at harvesttime and may affect practically the entire crop in seasons when large numbers of weevils are present.

about the last week in August; the actual date depends upon the time of hardening of the kernels and the presence of weevils. The females drill holes through the shucks and shells, and place an average of three eggs apiece in separate pockets within the kernels. The grubs emerge from the nuts between the



Figure 7.—Grubs of the pecan weevil: A, Nearly mature grubs within Stuart pecans; B, grubs emerging through holes in nuts.

The time when adult weevils emerge from the soil varies with the season and the locality. In central Georgia they usually emerge between July 15 and September 1, and in central Texas after periods of heavy rainfall in August or early in September. Egg laying begins

last of September and the last of December and sometimes later. They enter the soil to a depth of 4 to 12 inches and construct earthen cells, where they remain 1 or 2 years. They pupate between the first part of September and the middle of October and transform to adults in

about 3 weeks. These adults remain in the soil until the following summer. The complete life cycle requires from 2 to 3 years.

Control

DDT is the most effective insecticide yet found for the protection of pecans from weevils. Use 6 pounds of a 50-percent wettable powder to

When using bordeaux mixture for pecan-scab control, delay the last seasonal application of this fungicide until you make the first application of DDT for weevil control, since the two materials can be used together.

Toxaphene will also control the pecan weevil, and mites and aphids do not seem to increase as rapidly after its use as they do after the use



Figure 8.—Jarring to dislodge the weevils.

100 gallons of water or fungicide. Make two applications, the first when at least six weevils can be jarred onto a sheet spread on the ground beneath any tree known to have been infested in previous seasons, and the second 10 to 14 days later. The first application may be needed by the last week in July in Georgia, Alabama, Mississippi, and Louisiana, the first or second week in August in South and North Carolina, and after the first heavy rain late in August or early in September in Texas.

of DDT. Use 6 pounds of a 40-percent wettable powder or $2\frac{1}{2}$ pints of an emulsifiable concentrate containing 1 pound of toxaphene per pint or the equivalent of other formulations to prepare 100 gallons of spray. Toxaphene should not be used with bordeaux mixture but can be used with ziram or zineb.

To determine the time for the first insecticide application, start jarring the trees about a week before you expect it may be needed.

Jarring. If you have only a few pecan trees or are not prepared

to spray, you can reduce weevil injury about 50 percent by lightly jarring the limbs and gathering the weevils. You should begin jarring for control at the time indicated for determining spray dates and repeat weekly until about September 15. You need to jar only a few of the trees known to be the most heavily infested year after year until the first weevils are found. If the weather is dry, few weevils will be taken and fewer jarrings will be needed until rains soften the ground.

To collect the weevils, place harvesting sheets under the trees (fig. 8), and jar each limb lightly two or three times to dislodge the insects. Use a padded pole or a pole with a metal hook bolted to one end. It may be necessary to climb high trees and jar each limb with the foot. Pick up the weevils from the sheets and kill them by placing them in a bucket or can containing kerosene. The dislodged weevils will remain quiet on the sheets long enough to be picked up.

You can also reduce the weevils by gathering at harvest all nuts, both good and bad, those on the trees and those on the ground. The weevily nuts can then be destroyed by placing them in oil or burning them.

BLACK PECAN APHID

Several species of aphids infest pecan trees, but the most destructive is the black pecan aphid. Practically all important pecan varieties are affected. This insect sucks the sap from the leaves (fig. 9), and in some seasons causes premature shedding (fig. 10) during August and September. It is especially destructive in the South and Southeast, and at times causes serious dropping of leaves in other parts of

the Pecan Belt. The presence of bordeaux mixture or DDT on the leaves sometimes seems to cause the aphids to increase in numbers.



Figure 9.—Pecan leaf injured by the black pecan aphid. Note aphids on injured areas.

The first sign of injury to the leaflets is a bright yellow area where the insect has fed (fig. 9). This yellow area eventually turns brown. As the season advances and the aphids increase in numbers, the

entire leaf may drop prematurely. The aphids feed on both sides of the leaflets and prefer the shaded inner parts of the tree. As the injured leaflets drop, the aphids migrate toward the outside of the tree. The premature dropping of too many leaves cuts off the supply of plant food and may prevent the proper filling of the nuts and reduce the following year's crop.

to other trees. About 15 generations follow one another through the season, each mature aphid producing about 60 young. The insects may thus attain enormous numbers by the last of summer, though they may have been scarce early in the spring. With the approach of cold weather the insect lays eggs for the overwintering generation.



Figure 10.—Pecan trees defoliated by the black pecan aphid.

The black pecan aphid passes the winter in the egg stage in crevices in the bark. Late in March the eggs hatch into wingless aphids, which move out to the opening buds and leaves, where they feed until full grown. At first they are light green, but after feeding a short time they become dark green to almost black. When full grown, the aphids give birth to living young. Some of them develop wings and fly to other parts of the same tree or

Control

The black pecan aphid can be controlled with a nicotine sulfate spray. Use $\frac{1}{2}$ pint of nicotine sulfate (40-percent nicotine) per 100 gallons of water with 2 quarts of summer-oil emulsion or with bordeaux mixture as used for pecan scab. It can also be controlled with a parathion spray. Add 1 pound of 15-percent parathion wettable powder per 100 gallons of water,

alone or in combination with fungicides. A 1-percent parathion dust has also been effective against light infestations. Airplane applications of 1 pint of 40-percent TEPP in 5 gallons of water per acre have also been effective in Georgia, and of 4 pounds of 25-percent parathion or its equivalent in 5 gallons of water per acre in Louisiana. See Precautions, page 51.

The black pecan aphid varies so much in its abundance that no set spray schedule can be given for its control. For best results begin treatments as soon as yellow spots appear on the foliage. In some seasons this may be as early as May, in other seasons it may not be necessary. A single treatment may hold the aphid population in check for 3 weeks or more. Be sure to cover both surfaces of the leaves with the spray. Give special attention to the inner parts of the trees, where the aphids are usually most numerous early in the season. It is useless to apply a spray after many of the leaves have dropped and the aphid population is large.

If sufficient mites are present to require treatment, apply an insecticide such as parathion, that will control both mites and aphids at the same time. For more information on mites, see page 23.

PLANT BUGS

The southern green stink bug (fig. 11, A), the leaf-footed bug (fig. 11, B), and similar bugs sometimes cause black pit and kernel spot of pecan nuts. Black pit is indicated by a darkening of the inside of the immature nuts, which is followed by premature dropping. The bugs cause this condition when the nuts are in the water stage of development, before the shells

harden. The pecan weevil and the hickory shuckworm cause a somewhat similar condition.



Figure 11.—A, Southern green stink bug; B, leaf-footed bug. Enlarged.

Kernel spot (fig. 12) consists of brown spots from $\frac{1}{16}$ to $\frac{3}{16}$ inch in diameter forming a pithy, porous area. The injury cannot be detected until the nuts have been shelled. The spots are bitter, but this bitter taste does not extend to the rest of the kernel. The bugs

cause kernel spot after the shells begin to harden and while the kernels are forming.

The severity of black pit and kernel spot varies with the abundance of plant bugs in an orchard. The abundance of plant bugs in turn depends on the native plants or cover crops present on which they breed.

The various plant bugs that cause black pit and kernel spot have somewhat similar life habits. Only the life habits of the southern green

which fly to the trees from the plants on which they developed.

Control

The use of proper cover crops and orchard sanitation are the best methods of controlling plant bugs that cause black pit and kernel spot. Do not plant cowpeas, soybeans, or *Crotalaria striata* as summer cover crops in or near the orchard. Till the soil in the orchard two or three times during the summer to destroy

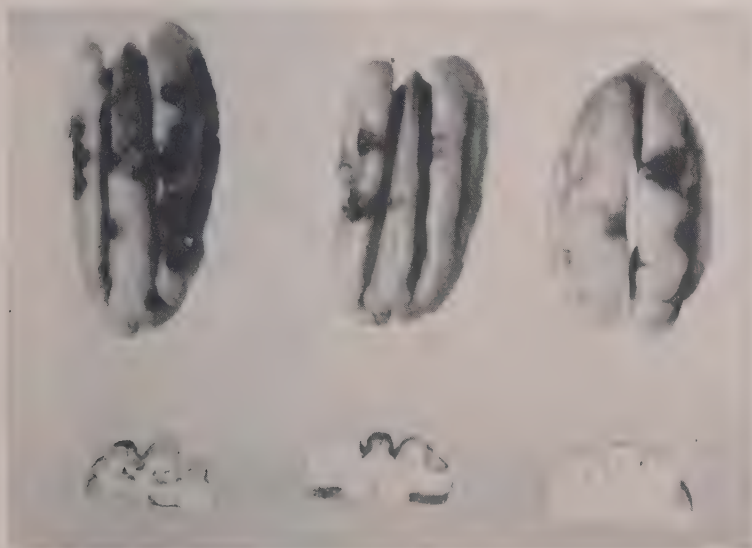


Figure 12.—Kernel spots on the ridges and edges of the kernels on Schley pecans.

stink bug, which is usually the most prevalent, will be discussed. The shield-shaped stink bugs, about $\frac{1}{2}$ inch long, spend the winter in trash or similar shelter in or near the orchard. In the spring they lay eggs in clusters underneath the leaves of weeds, cover crops, or other low-growing plants. These plants serve as food for the bugs until they become full grown. There may be as many as four generations a year. Pecan nuts are attacked only by the mature bugs,

wild hosts, such as beggarweed, thistle, jimsonweed, and maypop. For soil-building crops use winter legumes, such as hairy vetch, Austrian winter peas, and blue lupine.

None of the older insecticides will control these bugs. Some of the new materials may be of value, but they have not yet been tested for this purpose. For information on the effectiveness of the new insecticides for plant bug control consult your State agricultural experiment station or Extension entomologist.

PECAN LEAF CASEBEARER

The pecan leaf casebearer occurs most commonly in northern Florida and the southern parts of Georgia, Alabama, Mississippi, Louisiana, and Texas. This insect seldom causes serious injury to well-cared-for trees, for such trees put out

the spring the small larvae leave their winter cocoons and attack the unfolding buds and foliage (fig. 13). On reaching maturity they transform to pupae within cases that they have constructed about themselves while feeding. The small, grayish-brown moths appear from about the middle of May until



Figure 13.—Young pecan buds injured by larvae of the pecan leaf casebearer.

their foliage rapidly, before the insect can inflict much damage in the spring. On the other hand, weakened trees put forth their growth slowly, and thus enable this insect to eat the buds and small leaves faster than growth occurs.

The insects pass the winter as immature larvae in small cocoons about the buds, similar to those constructed by the nut casebearer. In

the first part of August. The moths deposit their eggs on the lower surface of the leaves along a vein or near the junction of a vein with the midrib. The young larvae that hatch from these eggs feed sparingly from their little winding cases (fig. 14) on the under side of the leaves. Although they may feed from the middle of May until November, they rarely attain a

length of more than $\frac{1}{16}$ inch by fall. Late in August or early in September the immature larvae leave their cases on the under surface of the leaves and migrate to the buds, where they construct their winter cocoons. The insect passes through but one generation a year.



Figure 14.—Feeding cases and injury to lower surface of pecan leaf by newly hatched larvae of the pecan leaf casebearer. Enlarged.

Control

The sprays applied against the nut casebearer also control the leaf casebearer. In orchards where a

spray for the nut casebearer is unnecessary, you can control the leaf casebearer by spraying the trees either when the buds begin to open or near the end of July. Use 2 pounds of a 50-percent DDT or 15-percent parathion wettable powder or 3 pounds of lead arsenate per 100 gallons. The benefits of the later spray will not be realized until the following season. If you are following a spray schedule to control scab, add the insecticide to the second prepollination spray in the spring if two prepollination sprays are recommended, or to the last fungicide spray in July. One thorough application is sufficient and, if you apply a spray in July, direct it as much as possible to the under side of the leaves, where the larvae feed. See Precautions, page 51.

SPITTLE BUG

The spittlebug is common on pecans in northern Florida and elsewhere along the Gulf coast. It also occurs along the Atlantic Coast from Massachusetts to Florida and westward to Kansas. The young bugs, usually several together, produce masses of white, frothlike material about the buds, tender shoots, or nut clusters (fig. 15) in the spring and early summer. The frothy masses presumably protect the young bugs from insect enemies. The full-grown spittlebugs, commonly called froghoppers, may be found on various shrubs and trees.

Control

Spittlebugs do not usually cause sufficient damage to make spraying necessary. If they do become abundant in an orchard, they may be controlled with one application of parathion or nicotine sulfate about the middle of May. Use either 2 pounds of 15-percent para-

thion wettable powder or 13 fluid ounces (about $\frac{3}{4}$ pint) of nicotine sulfate (40-percent nicotine) with 3 quarts of summer-oil emulsion to 100 gallons of water. If you are using a scab-spraying schedule, add the parathion or nicotine sulfate to 100 gallons of fungicide in the second application. See Precautions, p. 51.



Figure 15.—Pecan nut cluster showing spittle-like substance produced by the spittlebug.

FALL WEBWORM

Fall webworms feeding in colonies make unsightly webs (fig. 16) on pecan trees during the summer and fall. Usually all the members of a colony hatch from a mass of eggs deposited on a leaf by a single moth. The caterpillars feed (fig. 17) on both surfaces of the leaves, and enlarge the web as they need more leaves. When full grown the caterpillars are a little more than an inch long and are covered with long white and black hairs. They spin flimsy cocoons beneath loose

debris on or just below the surface of the soil. Usually there are two broods a year. The second brood, ordinarily the larger, feeds during the fall.



Figure 16.—Young pecan tree defoliated by the fall webworm.

Control

Fall webworms can be killed with a spray containing an arsenical, DDT, or parathion. Use 3 pounds of lead arsenate or calcium arsenate or 2 pounds of 50-percent DDT or 15-percent parathion wettable powder per 100 gallons of water. To prevent possible injury to the foliage, use a weak bordeaux mixture (2-1-100) with either arsenical. Control is needed only when the insect is very numerous in an orchard and should be attempted when the caterpillars are small. See Precautions, page 51.

If there are not many webworms in the orchard, it may be more prac-



Figure 17.—Web and caterpillars of the fall webworm.

tical to remove the webs from the trees before the caterpillars have left them and preferably before they have done much feeding. Use a long-handled tree pruner or a bamboo pole with a hook at the end.

WALNUT CATERPILLAR

Walnut caterpillars feed in groups, often eating all the leaves on small trees or on certain limbs of large trees (figs. 18 and 19). They do not form webs on the leaves. In the South the first generation appears in June and July, and the second generation in late August and September. As they grow, the



Figure 18.—Walnut caterpillars clustered on trunk of pecan tree. (Courtesy of Florida Agricultural Experiment Station.)



Figure 19.—Colony of walnut caterpillars on a pecan shoot. (Courtesy of Florida Agricultural Experiment Station.)

caterpillars molt, or shed their skins several times. In preparation for molting they go down to a large limb or to the trunk of the tree and

form a compact mass. After shedding their skins, they go back toward the ends of the branches and resume their feeding.



Figure 20.—Twig girdler girdling a pecan branch.

Control

The same spray treatments recommended for the fall webworm will control this insect. Caterpillars clustered on the trunk or limbs of a tree (fig. 19) may be destroyed by crushing or burning.

TWIG GIRDLER

The twig girdler often girdles the twigs of pecan and other trees late in the summer and during the fall (fig. 20). The injured branch may break off and drop to the ground, or remain on the tree. This insect is generally present wherever pecans are grown. It is especially abundant in orchards near timberland where hickories and persimmons abound, and may inflict serious damage on young trees. On older trees several clusters of nuts may be lost with each twig that is severed. Pecan nursery trees may likewise be attacked if they are near timberland where the twig girdlers are prevalent.

Twig girdlers are brown beetles $\frac{1}{2}$ to $\frac{5}{8}$ inch long. They lay eggs in the twigs that they girdle, and these eggs hatch into whitish, leg-

less grubs. The grubs make little growth during the fall and winter months, but in the spring they grow fast and tunnel in the twigs. They complete their growth and transform into beetles during the latter part of August. Usually one year is required for development of the insect, although some individuals do not complete development until the second season.

Control

Gather and burn the severed branches late in the fall or in the winter or early spring, when the eggs and grubs are in the twigs. Gather all branches lodged in the trees as well as those on the ground, and also those from infested nearby trees, such as hickory and persimmon.

Recent tests indicate that sprays containing DDT or parathion may be effective against this insect. Use 4 pounds of a 50-percent DDT wettable powder or 3 pounds of a 15-percent parathion wettable powder per 100 gallons of water. Make three applications at 2-week intervals, beginning when the first injured branches are noticed late in August. See Precautions, page 51.

PECAN PHYLLOXERA

Swellings, or galls (fig. 21), occasionally appear on leaves, leaf-stalks, succulent shoots, or nuts of the current season's growth. These



Figure 21.—Galls of phylloxera on a pecan twig.

galls are caused by small insects known as phylloxera, which are closely related to aphids. One or more species are found in practically all sections of the Pecan Belt, but only one has been reported as doing serious damage. The attack of this insect causes the twigs to become malformed, weakened, and

finally to die. Sometimes an entire limb may die. Especially serious damage has been reported from Louisiana, Mississippi, Texas, and Arkansas.

The insects pass the winter in the egg stage in protected places on the branches. The young appear in the spring about the time the buds unfold. They insert their beaks into the new growth, and a gall forms, which soon envelops the insect. The insect matures within the gall and lays a large number of eggs. The young insects that hatch from these eggs develop into winged forms. Usually late in May or early in June, the gall splits open and releases the insects.

Control

Spray the trees thoroughly with a mixture containing about $\frac{3}{4}$ pint of nicotine sulfate (40-percent nicotine) plus $2\frac{1}{2}$ gallons of lime-sulfur or 2 quarts of summer-oil emulsion per 100 gallons of water. Use the mixture containing lime-sulfur if the infestation is heavy to severe, or use either mixture against light to moderate infestations. Apply the spray during the delayed dormant period until buds show 1 to 2 inches of new growth, before the galls appear.

BHC, lindane, and dinitro compounds have also given good control of the pecan phylloxera. To make 100 gallons of spray use $2\frac{1}{2}$ pounds of BHC containing 10 percent of the gamma isomer, $1\frac{1}{4}$ pounds of lindane, 3 quarts of 36-percent dinitro-*o*-sec-butylphenol liquid, or a mixture containing 2 pounds of 40-percent dinitro-*o*-cyclohexylphenol powder plus a 2-percent dormant oil emulsion. Use the dinitro materials only during the period from late February until the buds begin to swell.

OBSCURE SCALE

The obscure scale is an important pest of both native and improved varieties of pecans in Texas, Louisiana, Arkansas, and Mississippi. It also occurs in other parts of the Pecan Belt. Its body is covered with a circular scalelike substance, usually dark gray, similar to the color of the bark, so that the insect is difficult to detect until it becomes abundant. It attacks the branches and trunk of the tree. The bark of heavily infested branches appears roughened or scaly (fig. 22).

This scale insect sucks the sap from the tissues. The greatest injury comes from the gradual killing of branches less than 3 inches in diameter. Larger branches are seldom killed, though they may be so weakened that they will not produce normal nuts. The slow, progressive killing of infested branches reduces the number of fruiting shoots and weakens the tree, making it subject to attack by borers.

This insect has but a single generation each year. The young, or crawlers, are present from about the middle of May until early in August. Soon after they hatch, the crawlers settle, insert their beaks, and begin to form their waxy scale coverings. They gradually increase in size and, except for the adult males, do not move around.

Control

Spray infested trees thoroughly with a dormant-oil emulsion before the buds begin to swell and preferably in January or February. If the trees are in a weakened condition, use a spray material containing 2 percent of oil, but if they are vigorous, use one containing 3 percent of oil. Weak, slow-growing

trees are more subject to oil injury than are vigorous trees. Commercial oil emulsions are made in different strengths; dilute them to the desired strength according to the directions on the container.

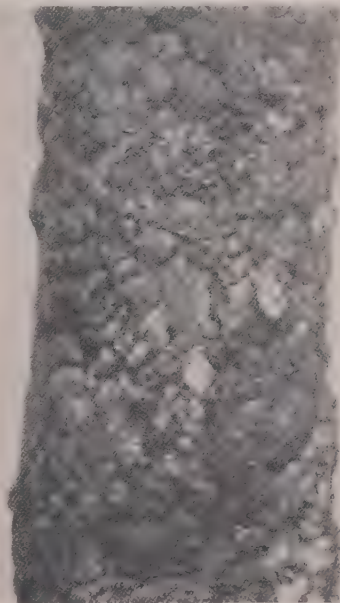


Figure 22.—Obscure scale on pecan twig. Enlarged.

MITES

Several species of mites attack pecans throughout the Pecan Belt. A heavy infestation causes serious loss of foliage. The most common and injurious mite is known only by its scientific name, *Tetranychus bicoriae*. It is a pale-green, eight-legged creature, so small that it is barely visible without magnification. It feeds principally on the under side of the leaves, but may occasionally be found on the upper side. Infested leaflets first show a slight discoloration about the midrib, where the mites usually start to feed. Later the discoloration

spreads outward, and the leaflet looks as if it has been scorched. Fresh scorch injury appears as dark brown or liver-colored blotches, and old scorch injury as dead areas of irregular size and pattern. Severely injured leaflets turn brown and drop off. An infestation generally starts on the lower branches of the pecan tree and spreads upward.

The life history and habits of *hickoriae* have not been studied in detail, but they seem to be similar to those of the two-spotted spider mite, a species that occurs on many kinds of plants throughout the United States. Injury has been observed in June, but seems to be the most severe during August, September, and early October. The mites develop most rapidly in hot, dry weather. There are several generations each year.

Other species of mites sometimes occur along with *hickoriae* or instead of it, particularly in Louisiana and Texas. One species rolls the edges of the leaves, and others feed along the veins on the under side of the leaves. Abnormal increases in the numbers of mites have occurred following the use of DDT. However, damaging numbers may appear in unsprayed orchards.

Control

Spray the trees with 1 pound of 15-percent parathion wettable powder, or its equivalent, per 100 gallons of water, whenever a mite infestation becomes evident and before it has caused the foliage to drop. Look for mite scorching along the leaflet veins. If the infestation is heavy, make a second application after about 10 days. In the western portion of the Pecan Belt, where mites other than *hickoriae* are likely to occur, add 4 pounds of wettable sulfur to the

parathion spray. Treatments for mites can be combined with those for aphids and disease control, if needed at or near the same time. See Precautions, page 51.

FLATHEADED APPLE TREE BORER

The adult flatheaded apple tree borer (fig. 23) is present in pecan orchards from spring to late fall.

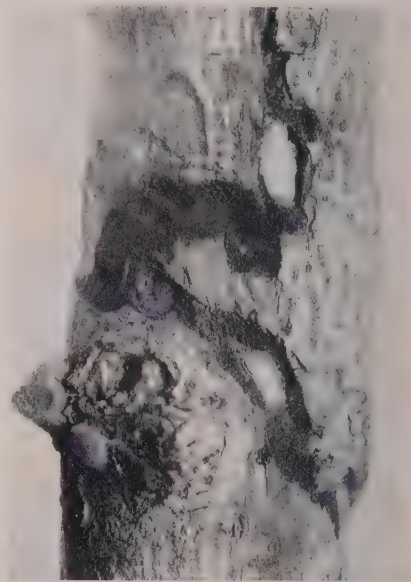


Figure 23.—A flatheaded apple tree borer feeding in wood of a tree.

It attacks pecan trees of nearly every age wherever they are grown. As a rule injury is confined to trees that have already been weakened from some other cause, such as those injured in cultivation, by cold, drought, or sunscald, or retarded by transplanting. Borers usually work on the sunny side of a tree trunk.

Injury results from the tunneling of the borers in the bark and sapwood of the trunk. Trees 2 inches or less in diameter may be

girdled and killed, and larger trees are weakened. The presence of one borer in a tree often leads to further attack. They disclose their burrows by pushing frass from the cracks in the bark. Injured spots can often be detected by the darker color and slight depression of the bark.

The adult beetles are about $\frac{1}{2}$ inch long, flattened and metallic in appearance. They lay their eggs in cracks in the bark or injured places on the sunny parts of the tree trunks. The larvae, or borers, are readily recognized by the large, flattened heads. The insect passes the winter in the borer stage and pupates in the spring. The development from egg to adult usually requires a year.

Control

The most effective way to prevent injury by these borers is to maintain vigorous trees by following approved practices of cultivation, fertilization, spraying, and conservation of soil moisture. You can protect newly transplanted trees by wrapping the trunks from the ground to the lower limbs with newspaper, burlap, or crepe paper of double thickness with asphalt between the layers. Wind the wrapping spirally or vertically, and hold it in place with a light cord. Apply the wrapping soon after the leaves appear in the spring and leave it in place as long as it is serviceable, provided the cord does not girdle the trees. Do not allow dying trees, cut logs, or prunings, which may be sources of infestation, to remain in or near the orchard during the spring and summer.

When trees are infested, remove the borers with a knife. Cut the wood as little as possible, to avoid drying the bark, which invites fur-

ther infestation. Hold the knife blade flat against the tree and work along the course of the burrow; trim the edges later. Removing the bark and frass from the deeper part of the burrow is believed to hasten healing of the wound. To keep the wood from drying until the bark heals over, paint the deeper parts with a pruning compound or with a mixture of 1 part of creosote and 3 parts of coal tar. Examine young trees at least once a year, preferably in March or April before mature borers emerge. If the infestation is heavy, examine trees during the summer for grubs overlooked.

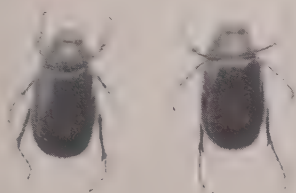


Figure 24.—May beetles.

MAY BEETLES

May beetles, or June bugs, sometimes defoliate pecan trees in the spring. Small trees surrounded by uncultivated land are most subject to injury. The beetles feed at night; in the daytime they lie hidden just beneath the surface of the ground.

The adult beetles (fig. 24) are $\frac{1}{2}$ to $\frac{3}{4}$ inch long, robust, and usually brown. They lay their eggs in the ground, and the larvae, which are the well-known white grubs, feed upon the roots of plants, particularly grasses. Larval development requires 2 years or more.

Control

Since the grubs of the May beetles feed in the soil, especially in sod land, they are seldom injurious in well-cultivated orchards that are some distance from uncultivated land. Fields near orchards are a source of infestation, but if the soil is plowed once a year, the May beetles are unlikely to become very numerous.

Beetles on small trees may be shaken onto sheets on the ground at night and destroyed. On both small and large trees control can be obtained with a spray containing lead arsenate, DDT, or parathion, when the beetles are first noticed. To make 100 gallons of spray material use 4 pounds of lead arsenate in 2-1-100 bordeaux, or 2 pounds of a 50-percent DDT or 15-percent parathion wettable powder in water. The bordeaux will protect the foliage from arsenical injury. If infestation persists, two or three spray applications may be necessary. See Precautions, page 51.

RED-SHOULDERED SHOT-HOLE BORER

The red-shouldered shot-hole borer makes small holes in the bark of pecan trees, which give the trunk the appearance of having been hit by shot (fig. 25). The first signs of these borers in a tree are light sawdust particles coming from the holes. Injury caused by severe drought or cold weakens trees for attack. Several similar insect species work on weak trees; some of them feed only on the bark and in the cambium region, and others go deep into the heartwood.

Control

To control these borers keep the trees in a healthy condition and as

far as possible reduce sources of infestation, such as dead trees and prunings. Application of a quick-acting fertilizer often assists in restoring an individual tree if it is not too severely weakened.



Figure 25.—Exit holes of adults of the red-shouldered shot-hole borer.

CURCULIOS

Two species of curculio, *Conotrachelus pecanae* and *aratus*, the latter known as the hickory shoot curculio, attack the unfolding buds and shoots on pecan late in March and in April in some areas of the Pecan Belt. Severe infestations occur most commonly on uncultivated pecans and in cultivated orchards adjacent to woodlands containing native pecan and hickory trees. In such trees 50 percent or more of the shoots may become infested. The larvae of *pecanae* tunnel in the buds and tender shoots and when present in large numbers may kill or weaken many nut-bearing shoots. Larvae of the hickory shoot cur-

culio tunnel within the shoots and leaf stems near the point where the leaves are attached, causing premature loss of foliage and weakening the shoots.

A third species, *Conotrachelus hicoriae*, attacks immature pecan nuts during late June, July, and early August in some parts of Louisiana, Arkansas, and Mississippi. The larvae tunnel in the nuts before the shells harden and cause them to drop. The injury is similar to that caused by the shuckworm. Damage appears to be light when the trees set a good crop of nuts.

Control

BHC and lindane have given fairly good control of *pecanæ*. Use 4 pounds of BHC (10-percent gamma) or 1½ pounds of 25-percent lindane wettable powder per 100 gallons of water. Apply when the buds show from ¼ to 1 inch of green growth or when jarring of the trees indicates that many adults are present. BHC has also been partially effective against *aratus* when applied shortly after the leaves begin to unfold or separate from the tender shoots. No tests have been conducted against *hicoriae*.

DISEASES OF THE PECAN

The pecan is affected by fungus, bacterial, and virus diseases and by environmental disorders of various kinds. Fungus diseases are caused by small, usually microscopic, plants. Bacterial diseases are caused by one-celled microscopic organisms, and the virus diseases by submicroscopic agents, the exact nature of which has not yet been determined. In contrast, the environmental disorders are caused by such conditions as a deficiency of one or more mineral elements (resulting in nutritional diseases), sudden changes in temperature, varying amounts of moisture, or other adverse nutritional or climatic factors.

Fungus diseases are by far the most numerous and widespread of the diseases that attack the pecan. For this reason they offer the most difficult problems in control. Bacterial and virus diseases are of much less importance. The environmental disorders may often be of considerable importance in certain localities, but because they are not infectious they are usually less serious in their effects and less difficult to control.

SCAB

Scab, a fungus disease, is one of the most destructive agents of the pecan, especially in the Southeastern States and in the southern portion of the Gulf Coast States. Its control is of major importance to the industry. Most of the older varieties that have been planted extensively are scabbing so badly that they produce poor-quality nuts or none at all in certain areas of high rainfall and high humidity. Only Stuart, one of the oldest and most widely planted varieties, is highly resistant to scab. The disease has been found on some nuts of this variety, but so far infection has never been severe enough to affect the quantity or quality of the crop. Moneymaker, Teche, and Curtis, varieties formerly considered immune, have now been found to be susceptible to scab in some localities. Fortunately, scab on Curtis is confined mostly to young trees growing in nurseries. Newer varieties that have been less extensively planted, such as Farley and Candy, appear to be highly resistant. Nevertheless, it seems probable that all

except Stuart will eventually be found to be susceptible.

The scab fungus attacks the rapidly growing tissues of the leaves, shoots, and nuts. When the affected tissues stop growing they become immune. Vigorously growing trees of scab-susceptible varieties are therefore more severely affected than are those in a low state



Figure 26.—Scab infections (black spots) on leaflets of the Schley variety of pecan in early spring.

of vigor. The greatest damage is done to the nuts, the loss of crop sometimes being complete. On highly susceptible varieties—such as Schley, Teche, and most of the western varieties—defoliation often results, especially when frequent infections occur beginning in early spring.

The scab fungus is carried over winter in the infected spots on old leaves and shucks or on the shoots of the trees. When weather condi-

tions become favorable in the spring, the fungus becomes active and produces spores. The spores are carried to the new leaves, shoots, and nuts, where they may cause further infections (fig. 26).

On varieties—such as Schley—that are highly susceptible to scab, initial, or primary, infections usually occur on the leaves. These may be followed by secondary infections. On varieties more resistant to scab—such as Farley, Desirable, and Stuart—primary infections do not usually take place on the leaves, but occur on the nuts relatively late in the growing season.

Infection of leaves, shoots, and nuts by the scab fungus occurs during cloudy, rainy periods of spring and early summer, when leaves remain wet overnight or for at least 12 hours. Under such favorable conditions as these, primary infections may occur before the middle of April. They develop rapidly. Spores can germinate and cause infection within 6 hours. It is generally 1 or 2 weeks, however, before scab lesions (diseased areas) can be observed on new tissue of either leaves or nuts. During damp periods new crops of spores are produced in unsprayed orchards by the last week of April or the first week in May. These spores cause secondary infections.

The primary infections are first observed as elongated, olive-brown lesions, usually on the veins of the under sides of the leaves. At first the spots are the size of pin points. They soon enlarge and coalesce. Later, with the development of secondary infections, large areas of the leaves may become almost black. On the nuts the spots of infection are small, black, and circular. At first they are slightly raised, but later they may become sunken. The nuts of highly susceptible varieties may be so extensively infected that

practically the entire surface of the nut will appear black.

Scab injury on Schley nuts is illustrated in figure 27. Of the five classes of nuts shown, only those of class E are unmarketable. Nuts in classes C and D are poor in quality, however. Severely infected nuts may drop prematurely, or they may almost stop growth and remain attached to the shoots indefinitely.

Control

To minimize scab infection, knock all old shucks and leaf stems off the trees before leaves begin to come out in the spring. If this is not done, infection of the foliage by rain-washed scab spores will probably occur. After a rain or on misty or foggy days, a slight jarring of branches will cause most of the old, wet shucks and leaf stems to fall. Wherever possible turn the shucks, leaf stems, and leaflets under with a plow, deep enough that they will not be turned up again by disk harrows or other cultivation machinery. Where winter cover crops are planted—a practice followed in most successful orchards—turning under shucks and leaves is not practicable. In such orchards it is imperative that the trees be thoroughly sprayed with a fungicide such as bordeaux mixture, ziram, or zineb, according to the general spray schedule on page 54.

Removal of low limbs will make it possible to plow near the trees. It will also let more sunlight through to the foliage and allow better air circulation, which will promote quicker drying of the leaves and nuts after rains and heavy dews. Low limbs may be cut from the trees, or in well-established orchards they may be defoliated by allowing livestock to browse on them.

Of all the materials tested for control of scab, home-made low-lime bordeaux mixture (page 51) has given the best results. Two

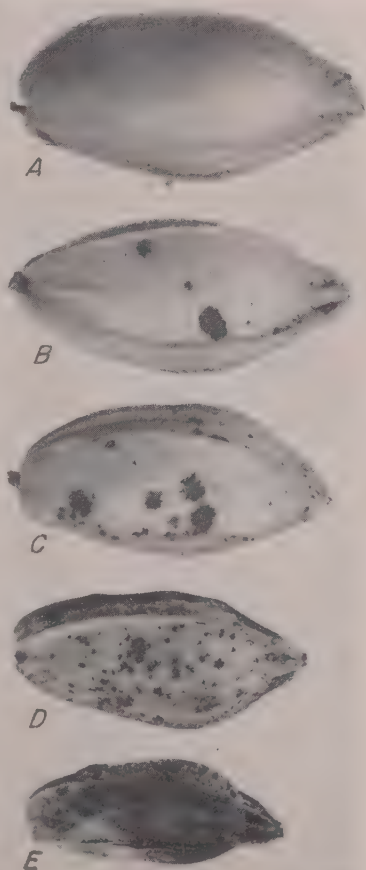


Figure 27.—Nearly full-grown nuts of the Schley variety classed according to degree of scab infection: A, No infection; B, one to three primary infections; C, four or more primary infections; D, a few secondary infections; E, many secondary infections.

new organic fungicides, ziram and zineb (page 52), when preceded by prepollination applications of low-lime bordeaux mixture, have given results comparing favorably with

those given by bordeaux mixture alone. Ziram and zineb are not only effective in scab control, but foliage on trees sprayed with these fungicides remains greener than the foliage of trees sprayed with bordeaux mixture alone. Also, use of ziram and zineb often does not increase the numbers of black aphids, as use of bordeaux mixture



Figure 28.—These nuts of the Schley variety were infected by scab early in the spring. Primary infections produced the black, sunken spots on the shucks. Secondary infection was prevented by three applications of bordeaux mixture, the last about July 15. Nuts are shown as they appeared on October 1.

is likely to do. By applying bordeaux mixture, ziram, or zineb according to the schedule on page 54, you can control scab to the point where it will cause only slight or no injury to trees.

Proper timing and thoroughness of the spray applications are important. Sometimes weather conditions are such that it is not possible to spray in time to prevent early infection on the young nuts. If later applications are properly applied to the trees, however, secondary infection can be prevented and nuts of good quality will probably be produced (fig. 28).

ROSETTE

Rosette is a nutritional disease caused by zinc deficiency. The disease occurs when there is not enough available zinc in the soil to meet the requirements for pecan tree growth and nut production.

Prior to the discovery in 1931 of the cause and control of rosette, most of the bearing pecan trees in the Southeastern States were affected by the disease. Since that time the soils of most pecan orchards in that area have been treated with zinc sulfate. Once rosette is controlled in this way, it is a minor problem and only an occasional application of zinc sulfate is needed thereafter.

Rosette can occur under various conditions throughout the areas where pecans are grown. The disease causes serious damage both in native groves and in orchards of improved varieties. The following soil conditions are most commonly associated with rosette: Lime-impregnated, sandy loam, loamy sand, and deep sandy soils deficient in organic matter; eroded soils with little or no surface soil remaining; and fertile soils that have been deeply and frequently cultivated or that have received too much fertilizer, especially nitrogen, potassium, or lime. A high percentage of the trees in young orchards that are intercropped annually to cotton, corn, or peanuts are likely to be affected by rosette unless they are treated with zinc sulfate.

In its earliest stages, or on slightly affected trees, rosette appears as a yellowish mottling of the leaves, particularly in the treetops. In its advanced stages the leaflets are slightly narrowed and crinkled. When the trees are severely affected, the leaflets are extremely narrowed and have reddish-brown areas or perforations between the

veins. New shoot growth is checked, the internodes are shortened, and the foliage is therefore bunched, or rosetted, in appearance. The name of the disease is derived from this characteristic.

poorly filled. Foliage on badly rosetted trees develops earlier in the spring than that on healthy trees, probably because of the pruning effects of the dieback. Symptoms of the disease on moderately or



Figure 29.—Pecan tree seriously affected with rosette. Dead branches can be seen at the top of the tree. Leaflets on other branches are small, narrowed, curled, and yellowish green. Figure 30 shows the same tree after treatment with zinc sulfate.

In the final stages of the disease, the shoots die back from the tips. Usually the dying back is confined to the current year's growth, but sometimes it extends to branches of considerable size. Seriously affected trees rarely bear nuts, and those borne are usually small and

severely affected trees become more pronounced as the season advances, and by October or November the trees appear at their worst. At this time the foliage of seriously diseased trees has a rusty or bronzed appearance, especially when viewed from a distance.



Figure 30.—The tree shown in figure 29 as it appeared 2 years later after rosette had been controlled by yearly broadcast applications of zinc sulfate to the soil.

Control

To correct the condition causing rosette, apply zinc sulfate in solution as a spray to the trees or as a dry salt on the soil. Trees recover most rapidly from the effects of rosette when they are sprayed, but soil applications are to be recommended because of the lasting effect. For mild cases of rosette, make three spray applications to the trees of a solution consisting of 2 pounds of zinc sulfate, analyzing approximately 36 percent zinc, in 100 gallons of water. Make the first appli-

cation as soon after pollination as possible and the other two at intervals of 3 to 4 weeks. This treatment must be repeated annually until all signs of the disease have been eliminated. Thereafter the trees should be closely observed for indications of the disease, since it is likely to reappear at any time.

To control scab and other parasitic diseases at the same time you treat rosette, you can combine zinc sulfate with bordeaux mixture. (See spray schedule, page 54). Increase the proportion of zinc sulfate used (4 pounds per 100 gallons of

bordeaux mixture), since the lime in the bordeaux mixture reduces the effectiveness of the zinc. To check the corrosive action of the zinc sulfate, rinse the spray pump and tank thoroughly after each day's spraying.

Applications of zinc sulfate to the soil may be somewhat more expensive than spraying because the chemical is often applied at higher rates. Such applications give more lasting control of rosette, however. Applications are usually effective and relatively inexpensive on acid, neutral, and light-textured alkaline soils. On heavy-textured alkaline soils or on soils that have a high fixing power for zinc, extremely high rates of application are usually necessary and spraying is generally preferable.

Apply zinc sulfate to the soil in the same manner as you would a fertilizer. If necessary you can mix it with a fertilizer. On soils that do not have a high fixing power for zinc or when trees are not severely rosetted, apply zinc sulfate at an annual rate of 5 pounds per tree. Severely rosetted trees require between 5 and 10 pounds of zinc sulfate annually for 2 or more years (figs. 29 and 30). The larger the dosage the first year, the greater will be the improvement from the diseased condition.

Make applications in late February or early March by broadcasting the zinc sulfate evenly beneath the trees, from near the trunk to beyond the radius of the limbs. To insure quick and positive incorporation, disk or plow the zinc sulfate into the soil, especially under the following conditions: On steep slopes that may wash, or on alkaline soils where the zinc may be fixed in the surface soil, or when there is not enough moisture to dissolve the salt and carry it down into contact with the absorbing roots. If you grow a winter cover crop in your orchard,

distribute the zinc sulfate evenly and in small amounts to avoid burning of the crop; delay cultivation if the chemical is applied in February or March as recommended.

DOWNY SPOT

Downy spot is a fungus disease affecting the leaves of pecans. It occurs throughout the southern pecan-producing region. The disease is usually seen first in late spring or early summer as downy or "frosty" spots on the lower sides of the leaflets (fig. 31). This appearance is due to production of spores by the fungus. Later, after these spores have been washed away or have deteriorated, greenish-yellow spots about $\frac{1}{8}$ inch in diameter remain on both sides of the leaves. These spots are clearly visible. As the season advances, the color of the diseased parts changes to brown. These portions of the leaves die, and the result is a premature defoliation of the trees.

The fungus causing downy spot lives over winter in the diseased leaves, where it completes its life cycle. In the early spring, especially during rainy periods, the new leaves are infected by the large number of spores expelled from the fruiting bodies in the old leaves.

All pecan varieties are attacked to some extent by the downy spot fungus, but Moneymaker and Stuart are among the most susceptible.

Control

To reduce infections of new leaves by downy spot, plow under old diseased leaves in the spring before tree growth begins and before the fruiting bodies release their spores. Spraying trees according to the general spray schedule (page 54), will control downy spot and other diseases, particularly scab.



Figure 31.—Characteristic white or "frosty" spots on the under side of a pecan leaflet caused by the downy spot disease in its early stages.

VEIN SPOT

Vein spot is a fungus disease that attacks pecan leaves. It is prevalent in the southwestern part of the Pecan Belt, including the States of Arkansas, Louisiana, Mississippi, Oklahoma, and Texas.



Figure 32.—Vein spot disease on a pecan leaflet. Spots are dark brown or black in the final stages of the disease.

The resemblance of the lesions of vein spot to those caused by scab on the leaves is so close that one disease may easily be mistaken for the other. The spots characterizing both diseases may originate on the veins of leaflets or on leaf stems (rachises) and are dark brown or

black in the final stages. On lateral veins lesions caused by vein spot are circular or oval and seldom attain a diameter of more than $\frac{1}{4}$ inch; on midribs of leaflets and on leaf stems spots are long and narrow. On midribs spots sometimes extend from the base to the apex of the leaflet. Unlike scab, vein spot does not attack the shoots or nuts, and the fungus apparently invades tissues of leaflets only a short distance on each side of the veins (fig. 32).

Because the vein spot fungus attacks and kills the growing tissues of leaves, premature defoliation often follows moderate to severe infections. If leaf stems are severely affected, the leaflets, and frequently entire leaves, drop prematurely. If leaflet stems (petioles) become girdled and die, leaflets may hang on the tree for a time. The Stuart variety appears to be more subject to the disease than are many other commercially important varieties.

The life history of the vein spot fungus is similar to that of most other fungi known to infect pecan leaves. It lives through the winter on fallen leaves. In the early spring it forms spores that are discharged into the air to infect new leaves with the disease.

Control

Where possible, use good sanitation practices and plow under leaves and stems that are likely to carry the vein spot fungus. To control the disease with fungicides, spray the trees once before pollination with 4-1-100 bordeaux mixture and once or twice after pollination with ziram, zineb, or 6-2-100 bordeaux mixture. Make the second application as soon after pollination as possible and the third 3 to 4 weeks later. (See general spray schedule, page 54.)



Figure 33.—Early stage of leaf blotch on the under side of a leaflet. The pimplelike fruiting bodies have just begun to form dark blotches.

LEAF BLOTCH

Leaf blotch is a fungus disease of nursery and orchard trees that is present throughout most of the pecan-growing region. It first appears as olive green, velvety tufts on the under surface of mature leaves in June or July (fig. 33). Yellow spots appear later on the upper surface of the leaves. Fruiting bodies—black pimplelike struc-

tures—make their appearance about midsummer. After the spores have been washed away by rain or have otherwise deteriorated, groups of these pimplelike structures unite, giving the leaves a black, shiny, blotched appearance. Occasionally these blotches join to envelop entire leaflets, causing premature defoliation of the tree.

The leaf blotch pathogen is a weak parasite and does not attack orchard trees unless they have been lowered in vigor by overcrowding, rosette, attacks by borers, or general neglect. Nursery trees are more susceptible, and the disease is especially prevalent where nursery blight is present. When trees are infected with leaf blotch, defoliation begins with the basal leaves. The disease gradually progresses upward until defoliation is complete except for a few leaves in the tops of the trees.

Control

Plow under old leaves in the early spring to insure as high a degree of cultural control of the leaf blotch fungus as possible. Chemical control measures used against scab and downy spot are also effective in controlling leaf blotch. Ziram, zineb, or a 6-2-100 bordeaux mixture will prevent the development of the disease. (See general spray schedule, p. 54.) In localities where only leaf blotch is present, spray the trees twice (first and second cover sprays) with any of these fungicides. Apply the first spray soon after pollination takes place and the second after an interval of 3 or 4 weeks.

BROWN LEAF SPOT

Brown leaf spot is a fungus disease of minor importance, especially on healthy trees. Although

it is found throughout the Pecan Belt, it causes serious premature defoliation only in localities where there is heavy rainfall or in orchards where trees are lacking in vigor as the result of neglect.



Figure 34.—Brown leaf spot on the under side of a leaflet. The diseased spots are often characterized by concentric markings (not visible in photograph).

Brown leaf spot first appears in June or July and is found only on the mature leaves. Primary infections are circular in outline (fig. 34) and are reddish brown in color, often developing grayish concentric zones. As the disease progresses the spots become irregular in outline. If not controlled, the disease may cause complete defoliation by the first of October. Like other fungi, the brown leaf spot organism is carried over winter in the infected spots on old leaves. The Stuart variety is especially susceptible to the disease; all other varieties are fairly resistant, particularly if a good cultural program is followed.

Control

To control brown leaf spot, spray trees once (any time between May 15 and June 15) with ziram, zineb, or a 6-2-100 bordeaux mixture. (See general spray schedule, page 54.)

LIVER SPOT

In some years a fungus disease known as liver spot does considerable damage to pecan foliage in central Mississippi, northern Louisiana, southern Arkansas, and eastern and central Texas. Evidence of this disease first appears in May or June as dark-brown circular spots on the lower surface of the leaflets, mainly along each side of the midrib (fig. 35). Spots are usually $\frac{1}{8}$ to $\frac{3}{8}$ inch in diameter. In September and October the color of the spots changes to a cinnamon brown, and at about the same time small, dark, spore-bearing bodies appear in the center of the spots. Leaflets with several spots will fall during September or October. If spring weather is damp and favorable for numerous infections, severe premature defoliation may occur.

The fungus causing liver spot survives the winter in a semidormant condition on the fallen leaves. Upon return of moist, warm weather in the spring, the fungus produces spores, which infect the new leaves.



Figure 35.—Early stages of liver spot on a pecan leaflet.

The foliage of strong, vigorous trees is noticeably more resistant to attack than that of trees whose vigor has been impaired by the keen competition of weeds and grasses for moisture and plant nutrients.

Control

Liver spot can easily be controlled by the use of a good fungicide. Spray trees once with ziram, zineb, or 6-2-100 bordeaux mixture. Apply in May, preferably after the middle of the month. (See general spray schedule, page 54.)



Figure 36.—Crown gall disease on nursery stock. Trees so infected should be burned to prevent further spread of the disease.

CROWN GALL

Crown gall is a bacterial disease that often causes economic damage to pecan trees. It was formerly considered to affect nursery trees only (fig. 36), but in recent years it has been found well established in orchards, especially on old trees, which it may affect so severely as to kill them (fig. 37). On trees of bearing age the disease is confined mostly to the large roots and base of the tree trunk, but occasionally smaller roots are also affected. Wartlike growths from a few inches to a foot or more in diameter, often extending several inches above the soil surface, characterize the orchard-tree development of the crown gall disease. Because of the fragility of the galls, they are often

broken off the roots. The galls may then become scattered on top of the soil when the orchard is being cultivated, thus spreading the disease.

Control

Dig up and destroy all nursery stock infected with crown gall, preferably by burning at the time of digging. When orchard trees become infected, remove soil around the crown of the tree, exposing large roots. Destroy the galls and paint the wounds with a mixture of 1 part creosote to 3 parts coal tar. This procedure may help to prevent the spread of the disease to healthy parts of the trees. Do not cultivate the soil near the trunks of infected trees.



Figure 37.—This 20-year-old pecan tree has been completely girdled by a large, wartlike growth caused by crown gall.

BUNCH DISEASE

The characteristic symptom of bunch disease is a bushy growth of slender, willowy twigs resulting from an abnormal forcing of lateral buds into growth. Bunch disease appears to be infectious. Ap-



Figure 38.—Effects of bunch disease on a pecan tree in early spring. Diseased branches often put out leaves about 2 weeks earlier than healthy ones.

parently no parasite is associated with the abnormal growth. In some respects symptoms resemble those of some virus diseases of other woody plants, such as peach yellows and bunch disease of walnuts.

In trees lightly affected with bunch disease, only portions of one

branch or of several scattered branches will show the characteristic symptom. The bunch growths are most conspicuous in spring and early summer because their development is earlier and greater than that of unaffected branches (fig. 38). Seriously affected trees be-

come mere skeletons of main lateral branches covered with a thick, broomy, sucker growth. On such trees many leaflets die and fall in late summer or early autumn; some shoots and branches also die, and few if any nuts are produced. Bunch disease spreads slowly through a tree. Several years may be required for all of a large branch to become diseased after the first evidence of infection appears. Bunchy growths may arise from the base of a tree or at a graft union, but similar growths may not appear elsewhere on the tree for several years.

Bunch disease may easily be confused with rosette. Two differences can be noted on leaflets, however. Those affected by bunch disease do not become yellow between the veins or extremely crinkled as do leaflets affected by rosette.

Bunch disease has been observed on a number of commercial pecan varieties as well as on wild trees. Different varieties show some difference in susceptibility to bunch disease. Trees of the Schley variety are probably the most susceptible, while those of the Stuart variety have shown the greatest resistance. Water hickory, a tree closely related to the pecan, is also susceptible to bunch disease.

The geographic range of bunch disease appears to be limited to areas having rich, alluvial soils in parts of Arkansas, Louisiana, Mississippi, Oklahoma, Texas, and New Mexico.

Control

No measures are known that will definitely control bunch disease. However, to minimize the effects of the disease, use for propagation bud or scion wood from disease-free trees only. It is imperative also to use only disease-free pecan or water

hickory trees as stocks in topworking native trees to standard varieties. Destroy any diseased pecan or hickory trees that may be growing wild in the vicinity of your orchard. On lightly affected orchard trees, you may be able to arrest the disease by pruning out diseased branches. Make the cuts well back from infected parts. Once a lateral branch is affected as far back as the trunk or a main limb of a tree, there is little hope of arresting the disease. Such trees should be destroyed.

WOOD ROT

Broken branches or other wounds on pecan trees provide possible points of entrance for wood-rotting fungi unless the injured surfaces are properly treated. Once these fungi gain entrance, they spread rapidly through the wood and may endanger the life of the entire tree.

Control

Cut off broken branches or limbs flush with the main branches or the trunk of the tree (fig. 39). Do not leave projecting stubs. They rarely heal over and thus continue to provide entrances for wood-rotting fungi. Smooth cuts heal more quickly than do those that have a rough or jagged surface. Paint the cuts with a mixture of 1 part of creosote to 3 parts of coal tar to protect the surface; repeat this treatment once a year until the wound has healed. This mixture is caustic and will slightly injure the cambium (growing layer), but the cut will generally remain free of wood-rotting fungi and will eventually heal. Commercial paints for tree wounds, having asphalt, tar, or vegetable gums as their base, may also be used to cover wounds.



Figure 39.—Tree at left has been improperly pruned. Wounds of this type heal slowly and provide entrances for wood-rotting fungi. Tree at right has been pruned properly and has healed rapidly. Cuts were made flush with trunk and treated with the recommended mixture of coal tar and creosote.

COTTON ROOT ROT

Cotton root rot is a disease caused by a soil-inhabiting fungus. The disease has been found in Texas and other States westward to the Pacific coast. Although cotton root rot most commonly attacks cotton and alfalfa, it is harmful to many other plants. It has killed pecan trees in both Arizona and Texas. The fungus is most active during the summer. Roots of the pecan usually become infected at this time. Injury to the roots reduces the moisture supply to the leaves, which can become dry enough within a few days to cause death of a tree.

Some trees continue to live through one or two seasons, however, after symptoms of the disease become apparent. In such cases the leaves may be yellow and sparse.

There is no practical means of controlling cotton root rot. It is suggested that growers avoid planting pecan trees where the soil is known to be infected with this fungus, especially where cotton or alfalfa has been grown.

POWDERY MILDEW

Powdery mildew is usually considered to be of minor importance on the pecan, although it occasionally causes serious damage to the nuts. This fungus disease affects both foliage and nuts, forming a white superficial growth (fig. 40) early in the growing season, generally in July. Premature defoliation of the trees occurs when conditions are especially favorable for the spread and development of the fungus. When the nuts are infec-

ted early in the growing season, those that develop may be small, the shucks may split prematurely, and the kernels may be poorly developed. During the winter the fungus remains dormant on infected leaves and shucks.



Figure 40.—Early stage of powdery mildew on pecan nuts of the Farley variety. The characteristic white growth has covered most of the surface of the nuts.

Control

To reduce infections caused by powdery mildew, plow under old leaves and shucks in the spring before spores are released. Control of the disease with fungicides is relatively easy if spraying is done at the right time. Spray trees twice with ziram, zineb, or 6-2-100 Bordeaux mixture. Apply as the third and fourth cover sprays with an interval of 3 to 4 weeks between applications. (See general spray schedule, p. 54.)

NURSERY BLIGHT

Seedling trees that are severely affected by nursery blight make little growth and are often too small for budding at the end of the second season. As its name implies, this disease is confined almost entirely to nursery trees.

The fungus that causes nursery blight invades both young and old leaflets. Infections begin in April, developing into small reddish lesions on both surfaces (fig. 41). Later in the growing season the spots on the upper surface turn ash



Figure 41.—Early stage of nursery blight on a pecan leaflet.

gray. Single lesions are usually about $\frac{1}{8}$ inch in diameter. These spots may be united by secondary infections to form a continuous lesion along each side of a vein. Secondary, or late, infections are most numerous along the midribs and larger veins. The diseased areas are soon killed by the invading fungus, and the tissues become brittle and break. The affected leaflets then have ragged margins and perforations.

Control

For the control of nursery blight, spray the trees once with 4-1-100 bordeaux mixture when the first leaves to form are half grown. This application is usually made between April 5 and 15. Follow this spray application with three applications of ziram, zineb, or 6-2-100 bordeaux mixture at intervals of 3 to 4 weeks. (See general spray schedule, p. 54.)

THREAD BLIGHT

Thread blight attacks pecans and many other woody plants in Florida and southern Louisiana. The fungus causing the disease overwinters in compact masses of tissues (sclerotia), which adhere to the bark of twigs and on leaf stems (fig. 42). Fungus threads grow rapidly from these masses onto the new leaf stems and leaflets in May and June. They spread completely over the lower surface of the leaflets and kill them, causing premature defoliation of the affected trees. Under particularly favorable conditions the fungus growing on the leaflets produces tiny spores (basidiospores). These are disseminated by wind, rain, and dew. Although little is known about these spores, they probably cause the widespread infections sometimes observed.

The most common symptom of thread blight disease during the summer is the matting together of the dead leaves. These matted leaflets hang from the shoots by weblike threads until winter and then fall to the ground.

Control

Pecan trees should not be planted near other trees that are affected by thread blight. The disease spreads rapidly in damp localities, especially where trees are crowded or neg-

lected. Where trees are crowded and infections are present, prune away the lower limbs or remove some of the trees. When infections become severe, spray the trees twice (second and third cover sprays)

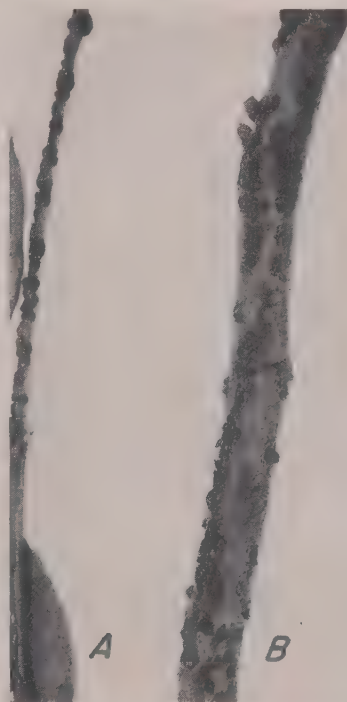


Figure 42.—Compact masses (sclerotia) of the thread blight fungus, A, on a leaf stem, and B, on a twig.

with ziram, zineb, or 6-2-100 bordeaux mixture. (See general spray schedule, page 54.)

GNOMONIA LEAF SPOT

Gnomonia leaf spot is another fungus disease of minor importance that affects the pecan. It is occasionally observed in Florida and the southern part of Georgia. Evidence of this disease first appears in June as small, inconspicuous brown spots. The spots may enlarge to $\frac{1}{2}$ inch or more in diameter and

become almost black. The shape of the spots varies from circular to greatly elongated. Characteristic of disease markings are the long, narrow, dead areas between the lateral veins (fig. 43). The disease has not

continues to develop after the nuts have matured. The fungus is able to penetrate the shell of thin-shelled varieties and enter the kernel. There it causes a decay known as "pink rot." Nuts affected with pink



Figure 43.—Late stage of gnomonia leaf spot on pecan leaflets. Outlining of the spots by the leaflet veins is characteristic of the disease.

become serious enough to justify the use of control measures. So far it has been found only on rosetted trees, which suggests that the fungus causing the spots is a weak parasite.

PINK MOLD

During late summer and early fall a pinkish fungus growth can frequently be observed on the shucks of nuts that have been attacked by scab (fig. 44). This pink mold gains entrance into the nuts mostly through the scab spots. It

rot leak oil and often give off a strong, rancid odor. The shells usually have an oily appearance.

Nuts of the Schley variety, particularly those grown on unsprayed trees in yards and small orchards, are often seriously affected by pink mold. Only a part of the crop may be marketable if many of the nuts have been infected.

Control

Pink mold attacks chiefly scab-infected nuts, and only when these nuts are still on the trees. After

harvest the mold does not spread from infected to sound nuts. To insure control of the disease, therefore, follow the spray program for the control of scab given on page 54.

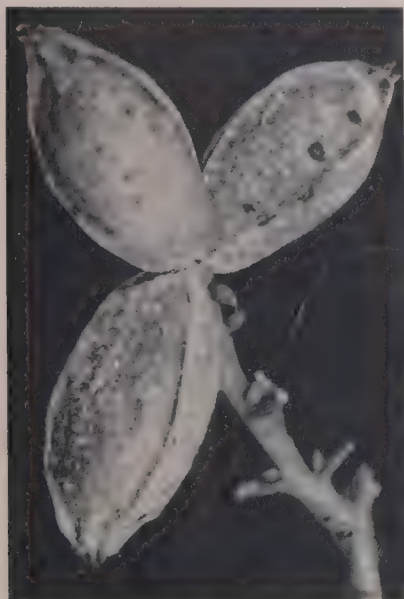


Figure 44.—Nuts of the Schley variety affected with pink mold. Scab lesions are visible on the nut at the upper right.

LICHENS

Lichens frequently occur on the trunks and branches of pecan trees, usually in the humid climate of the Gulf coast. These growths give the trees an unkempt appearance but are generally considered to be harmless.

Lichens are low forms of plant life that grow in humid localities. They are not single plants but are composite organisms made up of algae in enveloping meshes of fungus filaments. Like mosses, lichens obtain their food chiefly from air and water, and they attach themselves not only to trees (trunks, branches, and occasionally foliage)

but also to such inanimate objects as fence posts and rocks.

A common form of lichen is the grayish-green, paperlike growth that occurs on the bark of pecan trees (fig. 45). This irregularly



Figure 45.—Lichens on bark of pecan tree branch.

shaped growth may be anywhere from nearly an inch to several inches across. Its edges are usually lobed and curled upward.

Control

Because lichens are generally considered to be harmless to pecan trees, no spray program has been worked out for their control. However, almost any standard fungicide, including bordeaux mixture, lime-sulfur, or solutions containing organic coppers, will readily control lichens. These growths are never found on trees that are sprayed regularly with bordeaux

mixture for the control of scab and other pecan diseases.

SPANISH-MOSS

The common gray moss, or Spanish-moss (*Tillandsia usneoides*), oc-

Its nourishment is derived from the air, rain, and dew. It grows not only on trees but also on many inanimate objects. Large accumulations of Spanish-moss are detrimental to tree vigor and growth because of their shading effect (fig. 46).



Figure 46.—Spanish-moss almost completely covers this 35-year-old pecan tree. Such large accumulations are detrimental to tree growth and vigor.

casionally becomes unsightly and injurious on pecan trees. It is usually most troublesome in neglected orchards located in areas having poor air movement and high humidity, and especially when live oak trees are growing nearby. It is not a true moss but an epiphytic plant—one that has no true roots.

Control

Spanish-moss needs sunlight for best growth. To keep it in check, therefore, make sure trees in your orchard are vigorous so they will provide the utmost shade. An improved cultural and fertility program will usually invigorate trees

enough to keep the moss in check. Although no spray program has been developed to control Spanish-moss, the plant is rarely observed growing on trees that have been sprayed with bordeaux mixture, ziram, or zineb.

INJURY CAUSED BY CLIMATIC FACTORS

Winter Injury

Winter injury is a disorder usually found in young, vigorous, late-growing pecan trees. It also occurs in trees that have prematurely lost their leaves and then have put out new leaves late in the growing season. If such trees have not become dormant before freezing weather, their growing tissue is likely to be injured, particularly near the base of the trunk. During the next spring severely affected trees usually leaf out and appear to grow normally. However, as soon as hot weather begins, the leaves wither and the trees suddenly die.

Winter injury is easily detected. The bark on the injured area appears sunken and is cracked where it meets the growing tissue, which is discolored and sour smelling. The roots of affected trees seldom die, but sprout from below the dead trunks. Shot-hole borers and other insects are sometimes present, but their damage is of a secondary nature.

Proper cultivation, fertilization, and spraying do much to prevent winter injury. Cultivation should not ordinarily be continued later than midsummer. However, an orchard may be cultivated as part of the planting of winter cover crops in the fall, when trees are approaching dormancy. The trees should be fertilized only in early spring. Spraying to control diseases and leaf-destroying insects should be

done at the proper times. If these practices are followed, trees will have a good chance of escaping premature defoliation and of going into the winter in a mature and hardy condition.

Sunscald

Injury from sunscald is sometimes confused with winter injury. The symptoms are dead or cankerous areas, usually on the southwest side of a tree or on the upper surfaces of large branches. Like winter injury, sunscald occurs mostly on young trees, but it also occurs on older ones that have been cut back for topworking to some other variety. Bright sunshine, which raises the temperature of unshaded bark to the killing point, is probably the sole cause of sunscald in the summer. In the winter the condition is probably caused by the combined effect of bright sunshine and the sudden, usually severe, drop in temperature at the end of the day. The dead areas below the bark furnish ideal points of entrance for borers and other insects, and for wood-rotting fungi.

One of the best methods of preventing injury from sunscald is to head the young trees low so that the branches will shade the trunk. Because the lower limbs give protective shading to the trunks of young trees, they should not be trimmed off until the trees have made several years' growth. Wrapping the trunks of young trees with gunny sacks or whitewashing them will also aid in preventing sunscald.

Lightning Injury

Observations indicate that few orchards have escaped injury of one or more pecan trees by lightning. Such injury is often mistaken for the effect of some parasitic disease.



Figure 47.—The bark of the trunk of this tree was split to the ground by lightning. Some of the branches died in about 4 weeks, but the rest of the tree later recovered.

When a pecan tree is struck by lightning, the principal visible injury may be confined either to the limbs and branches or to the trunk (fig. 47). There may be a narrow split in the bark, extending from a branch in the top down the trunk to the ground, or the bark may be completely peeled from the trunk, especially near the ground (fig. 48). If the bark is only split, the tree usually survives; if the bark is peeled from the trunk, the tree dies

within a few weeks. Trees usually undergo partial to complete defoliation, depending on the extent of the injury. Leaves of affected areas first turn yellow and later drop. A tree can become completely defoliated within 30 to 60 days after being struck by lightning. Apparently definite signs of lightning injury are confined to the trees that receive direct hits.

There is no practical way to prevent damage from lightning in an

orchard, but dead and injured trees should be treated promptly. If a tree is killed, it should be destroyed. Otherwise it may become infested with borers that will probably spread to other trees. Dead limbs should be removed. Wounds left after pruning should be painted

Various spray materials have been recommended in this bulletin. Further information concerning these materials and means of applying them is given below.

INSECTICIDES

Nicotine Sulfate

Nicotine sulfate is commonly sold as a solution containing 40 percent of nicotine. It is a thick, brown liquid. For control of aphids on pecans, use it with bordeaux mixture as directed to control fungus diseases, or with summer-oil emulsion, 2 quarts per 100 gallons of spray, to serve as a spreader. In combination with summer-oil emulsion, it is also effective against the pecan phylloxera and pecan nut casebearer.

Lead and Calcium Arsenates

Lead arsenate and calcium arsenate are available as pink powders, primarily for use to control leaf-feeding insects. Both materials, especially the calcium compound, are liable to injure pecan foliage when they are applied to it in humid regions. In arid or semiarid regions lead arsenate is regularly used alone or with hydrated lime without apparent injury. Elsewhere the arsenical should always be combined with bordeaux mixture. As a corrective for arsenical injury the bordeaux mixture may be used as weak as 2-1-100.

DDT

DDT is available in several types of commercial preparations, but wettable powders are preferred for use against pecan insects. They contain various percentages of DDT and are ready for diluting in water to form a suspension.



Figure 48.—Pecan tree killed by lightning, shown as it appeared 3 months after having been struck. Note how bark was stripped from trunk.

with a mixture of coal tar and creosote as recommended for the control of wood rot. If injured trees are properly cared for, most of them eventually recover.

SPRAYING MATERIALS AND METHODS

Spraying is the best means of controlling most of the insects and diseases that attack pecan trees.

DDT acts as both a stomach poison and a contact insecticide, and is effective against the pecan nut casebearer, the pecan weevil, and a number of leaf-feeding insects. Affected insects do not die quickly. DDT spray deposits are very persistent.

DDT wettable powders can be used with such fungicides as ziram, zineb, wettable sulfur, fixed copper, and bordeaux mixtures of low lime content.

Outbreaks of mites and aphids may follow the use of DDT. Moreover, continued use of DDT may result in accumulations in the soil that will interfere with the growth of some crops that may be grown in the orchard. DDT residues in the soil disappear slowly, but may be considerably reduced after 4 or 5 years.

Summer-Oil Emulsions

Summer-oil emulsions are used with nicotine sulfate for the control of aphids, the pecan nut casebearer, and the pecan phylloxera, and serve principally as spreaders for the nicotine. They will also control mites. They should contain at least 80 percent of oil having a viscosity of not more than 70 seconds Saybolt and an unsulfonated residue of at least 85 percent. They are not likely to injure the foliage or nuts of the pecan when used as recommended. The composition of summer-oil emulsions and directions for diluting and mixing them are usually given on the containers.

Dormant-Oil Emulsions

In some sections of the Pecan Belt, growers may need to use an oil emulsion during the dormant and delayed-dormant periods to control the obscure scale, or other insects. Since the oils in dormant

emulsions have not been chemically treated for the removal of substances that may injure the foliage, they should not be used after the delayed-dormant period. Commercial products contain various percentages of oil. Follow directions on the container to obtain the recommended quantity of oil in the dilute spray.

Parathion

Parathion will control aphids, mites, and many other insects that attack pecans. It is available most commonly as 15- and 25-percent wettable powders for use in sprays and as 1- and 2-percent dusts.

Dinitro Compounds

Dinitro compounds such as dinitro-*o*-sec-butylphenol and dinitro-*o*-cyclohexylphenol are of value in the control of phylloxera. They are available in both powder and liquid forms. The powder form is generally used in combination with dormant oil, and the liquid form is diluted in water. These materials should not be used after the bud swelling period, as they are likely to injure foliage. Follow the manufacturer's directions closely for mixing.

BHC and Lindane

BHC and lindane are effective against phylloxera, aphids, and curculios. They are most commonly available as wettable powders and dusts. They do not injure fruit or foliage, but affect the flavor of some crops, especially if used close to harvest.

Toxaphene

Toxaphene is effective against the pecan weevil. Commercial

preparations containing toxaphene include emulsifiable concentrates and wettable powders. Emulsifiable concentrates may contain as much as 1 pound of toxaphene per pint, and wettable powders usually contain 25 or 40 percent of toxaphene. Toxaphene is not compatible with bordeaux mixture but can be used safely with ziram or zineb.

TEPP

TEPP is effective against mites and aphids. It is most commonly available as a 40-percent solution or a 0.75- or 1-percent dust. As it decomposes rapidly on exposure to moisture, it should be applied as soon as possible after being mixed with water or loaded in a duster. Residues deteriorate rapidly.

Precautions

Many of these insecticides are **poisonous. Handle them with care. Follow the precautions on the label.** Store them in plainly marked containers away from all food products and in places where children and domestic animals cannot reach them. When mixing and applying insecticides, take care to keep the materials out of the mouth and eyes and away from the tender parts of the body. Wash the face and hands thoroughly after applying any insecticide. After long exposure take a bath and change the clothes. Wash clothing on which spray residues have accumulated before wearing it again.

Parathion and TEPP are extremely toxic to human beings. Handle them with care and only in the open air or in a well-ventilated room. Wear rubber gloves. Avoid breathing in the wettable powder while opening the bags or putting the powder into the spray tank. If you are exposed to spray drift or

dust clouds, wear protective clothing and also a respirator that has been approved by the Department of Agriculture. In case the spray strikes the face or arms or the clothing becomes wet with it, remove the clothing immediately and wash thoroughly all exposed parts of the body. If headache, blurred vision, nausea, or other discomfort develops while working with these materials, stop work immediately, change your clothes, and bathe. If the illness persists, take an emetic such as mustard or warm soapy water and call your doctor. Atropine sulfate is an antidote for parathion. It may be obtained by prescription in 1/100-grain tablets. For severe poisoning take two tablets at once and get medical help.

Nicotine sulfate causes nausea in some people upon exposure to fumes from either the undiluted or diluted material. Acute illness can result from its absorption through the skin. If you spill concentrate on the skin, wash it off immediately. Do not continue to work in clothing that has become saturated with nicotine spray.

FUNGICIDES

Bordeaux Mixture

Bordeaux mixture of low lime content can be used safely, economically, and effectively for the control of pecan scab and parasitic leaf diseases. There is no better or cheaper form of bordeaux mixture known than that made at home with copper sulfate (bluestone), lime, and water. For simplicity of mixing, economy, and uniform quality of spray material, growers are advised to use the finely powdered, or "snow" form of copper sulfate and a high-calcium hydrated lime.

Finely powdered copper sulfate dissolves rapidly in water, as the

particle size is about that of granulated sugar. This form costs slightly more than the form with large crystals, but the added cost is more than offset by the time and labor saved in dissolving the material.

Hydrated lime can be purchased in 50-pound bags from most building-supply dealers. It should be 400-mesh and air-floated, and should contain at least 98 percent of calcium hydroxide. Hydrated lime has several advantages over quicklime: It is properly slaked when purchased, is relatively free from grit, deteriorates slowly if left in bags and stored in a dry place, and can be prepared as "milk of lime" in less time than quicklime.

A 6-2-100 formula for bordeaux mixture requires 6 pounds of powdered copper sulfate and 2 pounds of hydrated lime in enough water to make 100 gallons of spray material. Smaller or larger quantities of the same formula can be made by changing the amounts of each ingredient in proportion.

To make 500 gallons of 6-2-100 bordeaux mixture use the following procedure: Weigh out 30 pounds of powdered copper sulfate and 10 pounds of hydrated lime. Add about 10 gallons of water to the lime in a separate container to make milk of lime. The copper sulfate may be dissolved by placing it in the strainer of the sprayer tank while the tank is being filled with water. When the tank is about three-fourths full and all the copper sulfate is dissolved, add the milk of lime slowly. The agitator should be running so that the lime will be thoroughly mixed with the copper sulfate solution. After the milk of lime is added, finish filling the tank with water.

Bordeaux mixture can be combined with insecticides, except toxaphene, without loss of its effective-

ness. It is therefore possible to spray against insects and diseases in the same operation.

Ziram and Zineb²

Ziram and zineb are effective fungicides containing zinc salts of organic carbamates as the active agents and are available as dry powders. Both fungicides are compatible with insecticides such as nicotine sulfate, DDT, parathion, and toxaphene. Spray materials are usually prepared in the proportion of 2 pounds of chemical to 100 gallons of water.

To make 500 gallons of spray material, use 10 pounds of ziram or zineb. Place the chemical in a container and add enough water to make a paste. Add water to the paste until it becomes a slurry (thin, watery mixture). As the spray tank is being filled with water, preferably at the near-full stage, add the slurry. Delaying the addition of the slurry will permit a more nearly complete suspension of the zinc salts in the water. Zinc salts are heavy and soon settle to the bottom of the tank unless the mixture is constantly agitated while spraying is under way. One quart of summer-oil emulsion added to each 100 gallons will give the spray material a good sticking quality.

SPRAYING MACHINES

Portable spray outfits are commonly used for treating pecan trees. They are either equipped with 15- to 35-horsepower motors

² Ziram contains zinc dimethyl dithiocarbamate as the active agent; trade names for this material are Zerlate, Karbam White, Methasan, Zimate, and others. Zineb contains zinc ethylene bisdithiocarbamate as the active agent; trade names for this material are Dithane Z-78, Parzate, and others.

or driven by power take-off on tractors or trucks. The sprayer tank should hold at least 300 gallons. The machine should have a pump capacity of 20 gallons or more per minute and maintain a pressure of 400 to 600 pounds per square inch with the spray gun open. Trees from 40 to 60 feet high can be sprayed with machines of this type.

Since the operator must be prepared to spray parts of the trees at close range and parts at comparatively long distances, a spray gun that can be adjusted to produce either a wide-angled mist or a narrow, driving spray is preferable. Tree tops can be sprayed most thoroughly by standing on top of the spray machine or in a tower attached to the top of the machine. A hose $\frac{3}{4}$ inch in inside diameter is best.

A grower who has a small orchard of young trees can purchase a smaller machine than the ones described. If possible, he should buy from a dealer who carries a supply of parts and equipment for needed replacements.

Recently new types of spray machines have been used. These depend on a strong blast of air to carry the spray through the trees. Some are designed to apply spray materials in a more concentrated form than commonly used. On comparatively small trees satisfactory disease and insect control has been attained with these types of equipment. On large trees disease and insect control has not been as good with these new types of machines as with the high-pressure hydraulic machines.

WATER SUPPLY

The availability of water is as important as the selection of the spray machine. The supply should be centrally located, and if a well is used, an elevated water tank with

a capacity of several thousand gallons should be provided. The tank should have a 4-inch outlet, which will make it possible to fill a 500-gallon spray tank within 8 to 12 minutes. If the equipment and labor are available, much time will be saved by using a supply tank to haul water and spray materials directly to the spray machine.

APPLYING SPRAY MATERIALS

In applying spray materials it is essential that all leaves and nuts be evenly covered with a thin film of the materials. When applying concentrated spray materials or dusts be sure you have a machine with sufficient capacity to blow the material to and throughout the trees and drive slowly enough to permit thorough coverage of leaves and nuts. Give particular attention to the tops of the trees. If spraying is done properly, little or none of the material will run off onto the ground. Overspraying is wasteful, is not effective, and may injure the leaves.

It is desirable, whenever practicable, to combine and apply together the spray materials recommended for the control of both insects and diseases. This will save the time and labor required to apply them separately.

GENERAL SPRAY PROGRAMS FOR INSECT AND DISEASE CONTROL

Spraying according to the spray schedule on pages 54-55 will give commercial control of most of the important insects and diseases of pecans in nearly all areas. Detailed information on spray schedules applicable to more limited areas can be obtained from your county agent or the State agricultural experiment station.

General spray schedule for control of pecan insects and diseases

Name of spray and time of application	Insect or disease to be controlled	Spray materials (per 100 gallons)	Remarks
First prepollination spray, when buds are bursting and first leaves are showing.	Scab, downy spot,-----	4-1-100 bordeaux mixture-----	To prevent foliage injury, apply only when temperature is above 55° F.
Second prepollination spray, when first leaves are half grown.	Scab, downy spot, vein spot, nursery blight.	4-1-100 bordeaux mixture-----	
First cover spray, when tips of small nuts have turned brown.	Scab, downy spot, vein spot, leaf blotch, brown leaf spot, nursery blight. Pecan nut casebearer, pecan leaf casebearer, aphids, and mites.	6-2-100 bordeaux mixture or Ziram or zineb, 2 lb. 50-percent DDT, 2 or 3 lb. or 15-percent parathion, 2 lb. or Nicotine sulfate, $\frac{3}{4}$ pt. plus summer oil 2 qt. or (in semiarid areas) Lead arsenate, 6 lb. Zinc sulfate, 4 lb. in bordeaux mixture.	Use the smaller quantity of DDT in the Southeast and the larger quantity elsewhere. If pecan nut casebearer infestations are heavy, make a second application 1 week later with any of the insecticides listed. Use parathion if aphids and mites require treatment. (See precautions on parathion, p. 51.)
	Rosette-----		Reduce zinc sulfate to 2 lb. if bordeaux mixture is not used.
Second cover spray, 3 to 4 weeks after first cover spray.	Scab, downy spot, vein spot, leaf blotch, brown leaf spot, thread blight, nursery blight, powdery mildew.	6-2-100 bordeaux mixture or Ziram or zineb, 2 lb.	If fall webworms or walnut caterpillars are abundant, add 50-percent DDT, 2 lb. or 15-percent parathion, 2 lb.
	Rosette-----	Zinc sulfate, 4 lb. in bordeaux mixture.	Lead arsenate, 3 lb. per 100 gal. (See precautions on parathion, p. 51.) Reduce zinc sulfate to 2 lb. if bordeaux mixture is not used.

Third cover spray, 3 to 4 weeks after second cover spray.	Scab, brown leaf spot, liver spot, thread blight, nursery blight, powdery mildew.	6-2-100 bordeaux mixture <i>or</i> Ziram or zineb, 2 lb.	If sufficient aphids or mites are present to require control, use insecticides recommended on pp. 24, 50, and 51.
	Pecan leaf casebearer, aphids, and mites.	50-percent DDT, 2 lb. <i>or</i> 15-percent parathion, 2 lb. <i>or</i> Lead arsenate, 3 lb. <i>or</i> Zinc sulfate, 4 lb.	(See precautions on parathion, p. 51.) Use lead arsenate in 2-1-100 bordeaux mixture, if disease control is unnecessary.
Fourth cover spray, 3 to 4 weeks after third cover spray.	Rosette Scab, powdery mildew Pecan weevil	6-2-100 bordeaux mixture <i>or</i> Ziram or zineb, 2 lb. <i>or</i> 50-percent DDT, 6 lb. <i>or</i> 40-percent toxaphene, 6 lb.	Reduce zinc sulfate to 2 lb. if bordeaux mixture is not used. For best control of weevils, apply combination spray when as many as six can be jarred from a tree and again in 10 days to 2 weeks. Toxaphene may be mixed with ziram or zineb, but not with bordeaux mixture.

NAMES OF PECAN INSECTS

For reference there are listed below the common and scientific names of the insects mentioned in this bulletin:

Common name	Scientific name
Hickory shuckworm	<i>Laspeyresia caryana</i>
Pecan nut casebearer	<i>Acrobasis caryae</i>
Pecan weevil	<i>Curculio caryae</i>
Black pecan aphid	<i>Melanocallis caryaefoliae</i>
Southern green stink bug	<i>Nezara viridula</i>
Leaf-footed bug	<i>Leptoglossus phyllopus</i>
Pecan leaf casebearer	<i>Acrobasis juglandis</i>
A spittlebug	<i>Clastoptera achatina</i>
Fall webworm	<i>Hyphantria cunea</i>
Walnut caterpillar	<i>Datana integerrima</i>
Twig girdler	<i>Oncideres cingulata</i>
Pecan phyloxera	<i>Phylloxera devastatrix</i>
Obscure scale	<i>Chrysomphalus obscurus</i>
A mite	<i>Tetranychus hicoriae</i>
Flatheaded apple tree borer	<i>Chrysobothris femorata</i>
May beetles or June bugs	<i>Phyllophaga</i> spp.
Red-shouldered shot-hole borer	<i>Xylobiops basilaris</i>
Hickory shoot curculio	<i>Conotrachelus aratus</i>
Other curculios	<i>Conotrachelus pecanae</i> and <i>hicoriae</i>

PECAN DISEASES AND CAUSAL ORGANISMS

Name of disease	Causal organism
Scab	<i>Cladosporium effusum</i>
Downy spot	<i>Mycosphaerella caryigena</i> ✓
Vein spot	<i>Gnomonia nerviseda</i>
Leaf blotch	<i>Mycosphaerella dendroides</i> ✓
Brown leaf spot	<i>Cercospora fusca</i> ✓
Liver spot	<i>Gnomonia caryae</i> var. <i>pecanae</i> ✓
Crown gall	<i>Bacterium tumefaciens</i>
Cotton root rot	<i>Phymatotrichum omnivorum</i> ✓
Powdery mildew	<i>Microsphaera alni</i>
Nursery blight	<i>Elsinoe randii</i>
Thread blight	<i>Pellicularia koleroga</i> ✓
Gnomonia leaf spot	<i>Gnomonia dispersa</i>
Pink mold	<i>Cephalothecium roseum</i> ✓